ENDEMIC VASCULAR PLANTS OF THE INTERIOR HIGHLANDS, U.S.A.

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ABSTRACT

We evaluate the 36 endemic vascular plants of the Interior Highlands of Arkansas, Illinois, Kansas, Missouri, and Oklahoma. Most of the endemic flora of the region are herbaceous perennials, although nearly a quarter of the endemic plant taxa are annuals. An analysis of the community affiliations of the region's endemic flora reveals that most endemic taxa are associated with glade habitats maintained by edaphic conditions and fire. Riparian habitats and fire-maintained pine-oak woodlands are other habitat associations with significant endemic flora. The Ouachita Mountains region of the Interior Highlands contains a disproportionate representation of the endemic taxa relative to its area, although there is also a smaller cohort of endemics restricted to the Ozark portion of the Interior Highlands.

KEY WORDS: Interior Highlands, endemic flora, biogeography, biodiversity, Ozarks, Ouachitas, Arkansas, Illinois, Kansas, Missouri, Oklahoma

RESUMEN

Hemos evaluado las 36 plantas vasculares endémicas de las Interior Highlands de Arkansas, Illinois, Kansas, Missouri, y Oklahoma. La mayor parte de la flora endémica de la región son herbáceas perennes, aunque casi la cuarta parte de las plantas endémicas son taxa anuales. Un análisis de las preferencias de las comunidades de la flora endémica de la región revela que la mayoría de los taxa endémicos están asociados con hábitats pantanosos que se mantienen por las condiciones edáficas y el fuego. Los hábitats ripariosy bosques de pino-roble mantenidos por el fuego son los otros hábitats con elementos de flora endémica significativos. La región de las Montañas de Ouachita del Interior Highlands contiene una representación desproporcionada de taxa endémicos de esta área, aunque hay también una pequeña cohorte de endemismos restringidos a la parte de Ozark de las Interior Highlands.

INTRODUCTION

Lists of endemic taxa are valuable tools for defining the uniqueness and conservation significance of biogeographic regions (Takhtajan 1986) and in establishing biodiversity "hotspots" for conservation priorities (Diamond et al. 1997; Ricketts et al. 1999; Myers et al. 2000; Stein et al. 2000; Estill & Cruzan 2001). Few biogeographic regions, however, have detailed endemic vascular plant lists.

For example, only recently have endemic plant lists been developed for the Atlantic and Gulf Coastal Plain and the West Gulf Coastal Plain (Sorrie & Weakley 2001; MacRoberts et al. 2002).

The Interior Highlands physiographic region has been relatively well-described physically and biotically (Fenneman 1938; Foti 1974; Nelson 1985; Thom & Wilson 1980; Bryant et al. 1993; Nigh and Schroeder 2002; Skeen et al. 1993; Foti & Bukenhofer 1998; Delcourt & Delcourt 2000). The region has an extensive botanical literature, including floras and atlases (Steyermark 1963; Peck & Peck 1988; Smith 1988, 1994; Taylor & Taylor 1989; Peck et al. 2001; Yatskievych 1999), but it has no comprehensive list of endemic vascular plants, and most botanical information is compartmentalized by state.

As shown in Figure 1, the Interior Highlands are comprised of the Ozarks, Ouachitas, and Arkansas Valley sections, and include significant portions of Arkansas, Missouri, and Oklahoma, along with minor areas of Illinois and Kansas. This region has long been recognized as a geologically, physiographically, ecologically, and culturally distinct region of North America, and constitutes the only highlands in midcontinental North America. The Ouachita Mountains are east-west trending fold-belt ranges of intensely deformed sandstone, shale, and chert (Miser 1929). The northern ranges are long hogback ridges of sandstone separated by broad valleys. The southern ranges are sharp ridges of novaculite separated by narrow, stony valleys (Croneis 1930). The Arkansas Valley is a broad alluvial plain with isolated mountains that generally separates the Ouachita Mountains from the Ozark Plateau. Structurally, the Ozark Plateau is a dome that has been slowly uplifted and eroded, resulting in high levels of topographic, geologic, edaphic, and hydrologic diversity. Bedrock geology includes exposures of Precambrian igneous rocks surrounded by alternating zones of Paleozoic sandstone and carbonate sedimentary rocks (Nigh and Schroeder 2002). Both the Ouachita and Ozark portions of the highlands are characterized by rugged, dissected uplands with abundant exposed rocks and highly variable soil depths.

This paper enumerates the endemic vascular plants of the Interior Highlands, along with information about each species, its plant community affiliations and the ecological processes that maintain these species. These data can be used to focus activities on the habitats, ecological systems, and ecological process regimes in greatest need of conservation action. Glade is used here to mean, open herbaceous-dominated habitats with sparse tree and shrub cover, shallow soils, and abundant exposed rock.

METHODS

For this study, a taxon is considered to be endemic if its range essentially does not extend outside the Interior Highlands. Hybrid taxa are excluded from this list. Nomenclature generally follows Kartesz (1999).

We searched all available sources of information, including extensive con-

sultation with knowledgeable experts, to determine global ranges of species in the vascular flora of Arkansas, Illinois, Kansas, Missouri, and Oklahoma. This included general references such as Kartesz (1999), Kral (1983), Mohlenbrock (2002), Robison and Allen (1995), Smith (1988), Steyermark (1963), Taylor and Taylor (1989), Yatskievych (1999), Flora of North America Editorial Committee (1993–), and more specific papers (e.g. Tucker 1974; Weckman 2002). Also included were various lists of species of concern kept by the Arkansas, Illinois, Kansas, Missouri, and Oklahoma Natural Heritage programs and the Ozark, Ouachita, Mark Twain, and Shawnee National Forests[1].

Once the preliminary list was compiled, we investigated many of the same sources and additional ecological references to determine the plant community affiliation(s) of each species throughout the Interior Highlands. This determination involved developing a general plant community list for the Interior Highlands and assigning each taxon to the most appropriate plant community. We used The Nature Conservancy's classification at the ecological system level (Comner et al. 2003), making ecological system conceptually analogous to plant community as applied here. Some taxa were characteristically affiliated with two or more ecological systems. Ecological systems of the Interior Highlands are listed in Table 2.

RESULTS

Included below (Table 1) is an annotated list of the 36 vascular taxa endemic to the Interior Highlands, arranged alphabetically by family and genus. For each taxon, one or more characteristic plant community types are indicated in brackets after the plant name, using the numbers designated for each community in Table 2. For each species in this list, we also indicate the family, physiognomic profile, distribution pattern within the Interior Highlands – Ozarks (Oz), Ouachitas (Ou), or both – and additional relevant information and comments where applicable. The Arkansas Valley is included in the Ouachita section.

DISCUSSION

We identified a total of 36 endemic vascular taxa within the Interior Highlands; there are no endemic families or genera. There are 24 endemic species, and 12

[1]In addition to the taxa treated in this paper, six species of *Crataegus* (Rosaceae), *C. carollensis* Sarg., *C. harveyana* Sarg., *C. lanuginosa* Sarg. *C. latebrosa* Sarg., *C. nuda* Sarg., and *C. thermopegaea* Palmer, are recognized by Kartesz (1999) as being endemic to the region and other potentially endemic hawthorns have been proposed (e.g. *C. ouachitensis* Palmer) but Smith (1994) does not recognize them. Even though endemism is high in *Crataegus*, we have left this complex and incompletely understood genus off the list. There are reports of *Hamamelis vernalis* Sarg. (Hammamelidaceae) from southeastern Texas by Correll and Johnston (1970), Vines (1977), Nixon (1985), Jones et. al., (1997), and Turner et al. (2003), although Flora of North America (1997) states that this species is endemic to the Interior Highlands. Consequently, we have omitted *Hamamelis vernalis* from this treatment. A revision of the genus *Talinum* (Portulacaceae) currently underway may result in the addition of two endemic species to the Interior Highlands flora.

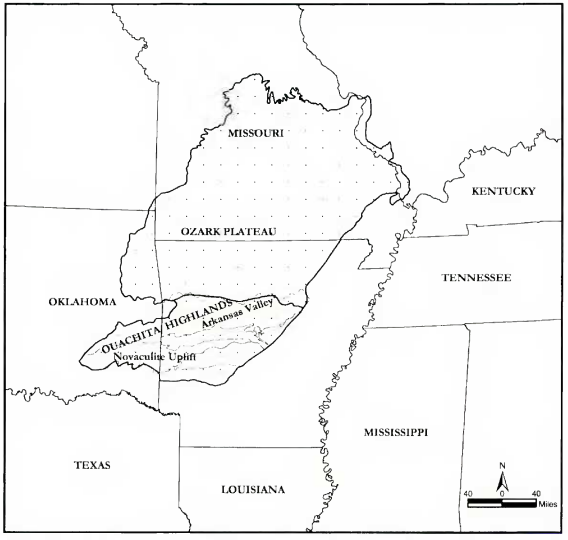

Fig. 1. Map of the Interior Highlands Physiographic Region.

endemic subspecies or varieties of more widely distributed species. Most of the endemic plant taxa in the Interior Highlands are on the Arkansas, Illinois, Kansas, Missouri, and/or Oklahoma Natural Heritage programs "species of concern" lists.

Most (58%) of the endemic vascular plants of the Interior highlands are perennial forbs; this parallels the physiognomy of the overall vascular flora of the region, as well as the ecoregions of midcontinental North America. Only three endemic taxa (8%) are woody, and there is a single endemic fern. Although only nine endemic taxa (25%) are annuals, this is a higher proportion of annuals than in the total native vascular flora of the region, and is likely reflective of the harsh conditions that characterize glade environments, which harbor a disproportionate component of annual species as compared to other habitats in the region.

TABLE 1. Endemic vascular flora of the Interior highlands with community associations in brackets (see Table 2). **Ou** = Ouachita Mountains, **Oz** = Ozark Plateau, **both** = both sections.

APOCYNACEAE

Amsonia hubrichtii Woods. [12] **both;** perennial forb

ASTERACEAE

Echinacea paradoxa var. *paradoxa* (J.B.S. Norton) Britt. [7] **Oz;** perennial forb

Liatris squarrosa (L.) Michx. var. *compacta* Torr. & A. Gray [8] **Ou;** perennial forb; center of distribution in the Novaculite Uplift subsection of the Ouachita Mountains.

Polymnia cossatotensis A.B. Pittman & V. Bates [14] **Ou;** annual forb; known only from the Novaculite Uplift subsection of the Ouachita Mountains.

Solidago ouachitensis C. & J. Taylor [6] **Ou;** perennial forb; center of distribution in the Novaculite Uplift subsection of the Ouachita Mountains.

Vernonia lettermanni Engelm. ex A. Gray [12] **Ou;** perennial forb

BRASSICACEAE

Cardamine angustata O.E. Schulz var. *ouachitana* E.B. Smith [4,5] **Ou;** perennial forb; known only from the Novaculite Uplift subsection of the Ouachita Mountains.

Lesquerella filiformis Rollins [7] **Oz;** winter annual forb; restricted to limestone glades, almost totally within the Springfield Plain subsection of the Ozarks.

Streptanthus maculatus Nutt. ssp. *obtusifolius* (Hook.) Rollins [8] **Ou;** annual forb

Streptanthus squamiformis Goodman [6] **Ou;** annual forb; known only from the Novaculite Uplift subsection of the Ouachita Mountains.

CAPRIFOLIACEAE

Viburnum ozarkense Ashe [5,12,14] **both;** shrub

COMMELINACEAE

Tradescantia longipes E.S. Anderson & Woods. [4,6] **both;** perennial forb; although known from both the Ouachitas and Ozarks, this species is especially characteristic in acidic woodlands on dissected uplands in the Current River drainage, and relatively rare elsewhere in the Interior Highlands.

Tradescantia ozarkana E.S. Anderson & Woods. [4,5,14] **both;** perennial forb

CYPERACEAE

Carex latebracteata Waterfall [5,6,12] **Ou;** perennial sedge

FABACEAE

Amorpha ouachitensis Wilbur [12] **both;** shrub

FAGACEAE

Quercus acerifolia (Palmer) Hess & Stoynoff [1, 13] **Ou;** tree; although long thought to be closely related to, or even conspecific with *Q. shumardii*, recent research indicates that this taxon is more closely affiliated with *Q. arkansana* (Williams 2003). The global population is less than 600 individuals.

HYDROPHYLLACEAE

Hydrophyllum brownei Kral & Bates [12] **Ou;** perennial forb; center of distribution in the Novaculite Uplift subsection of the Ouachita Mountains.

LAMIACEAE

Monarda fistulosa ssp. *fistulosa* L. var. *stipitatoglandulosa*, comb. nov. ined. [6,8] **both;** perennial forb; this taxon has apparently not been validly published at the varietal level, although Waterfall (1970) first described it at the species level, which was conceptually endorsed by Smith (1988).

Scutellaria bushii Britt. [7] **Oz;** perennial forb; restricted to dolomite glades, with the majority of the world's population in the drainages of the Current, Eleven Point, and White rivers.

LILIACEAE

Nemastylis nuttallii Pickering [7] **Oz;** perennial forb

POACEAE

Elymus glaucus Buckley ssp. *mackenzii* (Bush) J.J.N. Campbell [7,8] **both;** perennial forb

PTERIDACEAE

Pellaea glabella Mett. ex Kuhn ssp. *missouriensis* (Gastony) Windham [14] **Oz;** fern; this is the di-ploid, sexual variety of a wide-ranging species. Except for the spores, it is morphologically indistinguishable from the apomictic ssp. *glabella* (Wagner et al. 1965).

TABLE 1. continued

RANUNCULACEAE

Delphinium newtonianum D.M. Moore [4,5] **both;** perennial forb

Delphinium treleasei Bush ex K.C. Davis [7] **Oz;** perennial forb

RUBIACEAE

Galium arkansanum A. Gray var. *arkansanum* [6,8] **both;** perennial forb

Galium arkansanum A. Gray var. *pubiflorum* E.B. Smith [6,8] **Ou;** perennial forb; morphologically, this taxon appears closely related to the parent variety and needs further genetic evaluation. Known only from the Novaculite Uplift subsection of the Ouachita Mountains.

Houstonia ouachitana (E.B. Smith) Terrell [6, 8] **Ou;** perennial forb; center of distribution in the Novaculite Uplift subsection of the Ouachita Mountains.

SAXIFRAGACEAE

Heuchera villosa Michx. var. *arkansana* (Rydberg) E.B. Smith [12,14] **both;** perennial forb

Saxifraga palmeri Bush [12] **both;** perennial forb

Saxifraga virginiensis Michx. var. *subintegra* Goodman [1,13] **both;** perennial forb

SCROPHULARIACEAE

Agalinis nuttallii Shinners [17] **Ou;** annual forb

Penstemon cobaea Nutt. var. *purpureus* Pennell [7] **Oz;** perennial forb; although the typical variety is a wide ranging species of the prairie biome, this variety is restricted to glades on carbonate bedrock in the Interior Highlands.

VALERIANACEAE

Valerianella longiflora (Torr. & A. Gray) Walp. [1] **both;** annual forb

Valerianella nuttallii (Torr. & A. Gray) Walp. [1,8] **both;** annual forb

Valerianella ozarkana Dyal [7] **both;** annual forb

Valerianella palmeri Dyal [1,12] **Ou;** annual forb; center of distribution in the Novaculite Uplift subsection of the Ouachita Mountains.

The Ouachita Mountains comprise 25% of the total area of the Interior Highlands, but support 81% of the endemic taxa of the Interior Highlands. Fourteen taxa, representing 39% of the region's endemic plants, are found only in the Ouachita Mountains. Fifteen taxa (42%) are found in both the Ouachita and Ozark regions, while seven taxa (19%) are restricted to the Ozark Plateau. Also significant is that 25% of the endemic Interior Highlands flora is associated with the Novaculite Uplift subsection of the Ouachitas. This geologic substrate with its glades, woodlands, and stream complexes is an ecological hotspot for endemism within the Interior Highlands.

More than half (58%) of the endemic species in the Interior Highlands are associated with glade habitats (acidic, calcareous, novaculite). As defined by Nelson and Ladd (1982), glades are open habitats with strong lithologic control that are dominated by a characteristic herbaceous vegetation, with sparse tree and shrub cover, shallow soils, and often with abundant exposed rock. These exposed xeric or hydro-xeric habitats have extreme environmental parameters including long, usually annual drought periods in the growing season, limited water retention in the shallow soils, and intense solar heating. Many glades are also saturated through much of the dormant season, with frequent freeze-thaw cycles and associated soil upheavals. Drought and fire maintain most glades in a nearly treeless state.

The life histories of the endemic plants associated with glades show diverse

TABLE 2. Characteristic plant community affiliations of 36 endemic Interior Highland vascular plants. Numbers in the percent column refer to the percent of Interior Highlands endemic taxa occurring in this habitat type. All habitat types listed.

Community Complex	Number	Percent
1. Central Interior Highlands Dry Acidic Glade and Barrens	5	14
2. Ouachita Montane Oak Forest	0	0
3. Ozark-Ouachita Dry Oak Woodland	0	0
4. Ozark-Ouachita Dry-Mesic Oak Forest	4	11
5. Ozark-Ouachita Mesic Hardwood Forest	5	14
6. Ozark-Ouachita Shortleaf Pine-Oak Woodland	8	22
7. Central Interior Highlands Calcareous Glade and Barrens	8	22
8. Ouachita Novaculite Glade and Woodland	8	22
9. Arkansas Valley Prairie and Woodlands	0	0
10. Central Interior Highlands and Appalachian Sinkhole and Depression Pond	0	0
11. Ouachita Forested Seep	0	0
12. Ozark-Ouachita Riparian	9	25
13. Central Interior Acidic Cliffs and Talus	2	6
14. Central Interior Calcareous Cliffs and Talus	5	14
15. Ozark-Ouachita Fen	0	0
16. North-Central Maple-Basswood Forest	0	0
17. South-Central Interior Large Floodplain	1	3
18. Southeastern Great Plains Tallgrass Prairie	0	0

evolutionary traits that allow for survival in these habitats, but which presumably confer no competitive advantages in surrounding wooded habitat. For example, *Echinacea paradoxa* var. *paradoxa* and *Liatris squarrosa* var. *compacta* are shade-intolerant, long-lived perennials with either deep roots or water-holding subterranean tissues and grow in open habitats. The *Valerianella* species are vernal annuals that quickly complete their life cycles in the spring when conditions are relatively cool and wet; they are usually associated with those areas of the glade habitat that remain seasonally saturated due to water seepage. Species distributions may also be controlled by an affinity to particular substrates with specific lithological characteristic and mineral availability. For example, *Scutellaria bushii* is found only on dolomite; these glades are characterized by high levels of soluble cations such as magnesium and calcium.

Twenty-eight percent of the endemic flora occur in riparian habitats. Three (*Amsonia hubrichtii*, *Vernonia lettermannii*, *Valerianella palmeri*) of the ten endemic species found in riparian areas are associated with glade-like habitat structures, i.e. rocky, open habitats along ephemeral or intermittent streams. These habitats are xero-hydric, and maintained by flashy stream flows and soil conditions that make them seasonally xeric and nearly treeless.

We found that 22% of the endemic species are characteristically associ-

ated with dry pine-oak and oak woodlands. These plant communities are relatively open, with sparse to moderate tree cover, a diverse and well-developed herbaceous understory with a prominent graminiod component, and a relatively frequent fire regime. The endemic species associated with woodland habitats appear to be intolerant of both extreme exposure and deep shade. *Solidago ouachitensis*, for example, appears to require filtered sunlight but is not found in closed canopy forests or the more exposed glade habitats. Woodland plant communities are maintained in an open condition by fire and intermittent drought but have prevailing environmental conditions relatively less extreme and dynamic than the exposed glades.

Across the Interior Highlands region glades, open woodlands, and intermittent streams form landscape complexes that are closely associated on the landscape. These plant community complexes are maintained in an open or treeless condition by drought, fire, and flood. More than 80% of the endemic flora of the Interior Highlands occur in these landscape complexes.

The list of endemics presented in this paper will change as new information becomes available on plant community associations and species distributions, and as new taxa are discovered and others relegated to synonymy. However, it is now possible to compare the Interior Highlands region with adjacent regions that are physiographically different. For example, the 36 endemic vascular taxa of the Interior Highlands represent perhaps 2% of the native flora, but exhibit no patterns of endemism at or above the genus level. In fact, the Interior Highlands for all of its physiographic uniqueness, including age, long-term isolation from its moiety—the Appalachian Region—and its reputation as a "well-known refugium" (Meyer 1997) shows surprisingly little floristic uniquity from surrounding regions. By comparison, the West Gulf Coastal Plain with virtually no relief and no antiquity, has about 100 endemic taxa (about three percent of its flora) of which three are above the species level (MacRoberts et al. 2002). It is not known whether this same pattern and level of endemism occurs among other organismal groups, but there are suggestions that endemism rates may be higher than among the vascular flora. For example, there are 24 endemic crayfish taxa in the Ozarks (The Nature Conservancy 2003); this represents more than seven percent of North American Crayfish diversity. Preliminary data (Harris & Ladd 2003) indicate that the Ozark region is characterized by an unusually high level of undescribed lichen taxa, including at least two new genera, but current data gaps preclude determining levels of endemism.

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